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Optical coupling in the ETEM

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Environmental transmission electron microscopy is a proven characterization technique for materials science. Exposing samples to their operating environment can provide new insight into their working state. In the case of photocatalysis, the operating conditions include exposure to photons as well as a gaseous environment. By adding optical coupling to the transmission electron microscope (TEM) it is possible to gain insight in the fundamentals of their reaction mechanisms, chemical behavior, structure and morphology before, during and after reaction using *in situ* investigations.

Typically, photocatalysts work in gaseous or liquid atmosphere upon light illumination. Here, the aim is to reproduce their working conditions *in situ*. The Environmental TEM (1) allows exposing specimens to a controlled gas atmosphere, thus implementation of *in situ* sample illumination is needed. For this purpose, two novel specimen holders capable of shining light onto samples inside the TEM and to probe the sample using visible light spectroscopy techniques were designed and constructed (2). The holders were used to characterize photoactive materials in a simulated working environment and employed in the analysis of various photoreactive materials and structures. Novel information on the behavior of such materials during reaction was acquired in a reproducible fashion. In a wider perspective, the aim is to build a versatile experimental platform inside the microscope that allows electron microscopy under nonconventional TEM conditions and new kinds of *in situ* spectroscopy.

As an example of the a photoinduced reaction, the images below show metal impregnated GaN:ZnO before and after visible light illumination for 5 hours at $\lambda = 405$ nm in the presence of H₂O but in absence of electron beam. After illumination, Pt particles are clearly visible on the substrate surface.

1. T. W. Hansen, J. B. Wagner, R. E. Dunin-Borkowski, Aberration corrected and monochromated environmental transmission electron microscopy: challenges and prospects for materials science. *Mater. Sci. Technol.* **26**, 1338 (2010).
2. F. Cavalca *et al.*, In situ transmission electron microscopy of light-induced photocatalytic reactions. *Nanotechnology* **23**, (Feb, 2012).

